Analysis of Suitability of Evapotranspiration Waste Disposal Systems for Selected Semi-Primitive Mountain Environments

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Final Report

ANALYSIS OF SUITABILITY OF EVAPOTRANSPIRATION WASTE DISPOSAL SYSTEMS FOR SELECTED SEMI-PRIMITIVE MOUNTAIN ENVIRONMENTS

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INTRODUCTION

Sewage for individual, recreational dwellings is almost exclusively disposed of by privy or septic tank and drain field methods at the present time. Relatively large recreational facilities use either of the above two methods, a small holding pond system, or some sort of package treatment plant. Very few sewage treatment facilities of any size are found in the mountains. Hence, groundwater and surface water pollution is almost a certainty. Sewage infiltrating the soil frequently enters the nearby stream in a relatively short period of time. Disposal of sewage using a confined unit having no surface or subsurface outflow where the only means of removal of the sewage and water is by evapotranspiration and gases may be a feasible solution for individual dwellings in recreational areas. This type of unit eliminates pollution of both the surface and groundwater flows. The system will be called an evapotranspiration unit (ET unit).

There are several evapotranspiration systems that have been developed where highly impermeable soils exist. Experimental work on such evapotranspiration systems has been done in Toronto, Canada, (Berhart, 1965) and Victoria B.C., Canada, (Smith, 1965). Several western states include in their individual waste disposal books an above-the-ground evapotranspiration system called Nodak for individual dwellings (Witz, et.al., 1970, and Lupinus and Barker). Generally

speaking, however, all these systems at least utilize partial infiltration as part of the process. There is a commercial system available on the market called an Armon System that uses a liner to prevent infiltration but also has as part of the system an expensive holding tank. Information on the Armon system is rather scant. It is therefore felt that development of an efficient low initial and operating cost evapotranspiration unit with no pollution of surface and groundwater supplies should be investigated for individual summer recreational facilities.

This research report gives information on construction, cost, loading, efficiency, esthetics, and operating conditions for an ET unit to be used for waste disposal in semi-primitive mountain environments.

EVAPOTRANSPIRATION UNIT

The evapotranspiration unit being tested has no holding tank and no effluent from the unit. All material is held within the unit and is disposed of by evaporation and transpiration as well as by gases escaping to the atmosphere by biological processes. A ten-foot square pond in the center of the unit is utilized for evaporation and influent to the unit. The remainder of the unit is covered with grasses and alfalfa which transpire water to the atmosphere.

Although it has been shown that physical (Jones, 1965, and Rice, 1974) and biological (DeVries, 1972; Lance and Whisler, 1972; and Thomas, et.al., 1972) slimes sometimes clog soil and gravel fill areas when percolation is the method of liquid removal, inconclusive data is available when evapotranspiration systems are used. Surface spreading ponds have been shown to work (McGauhey and Krone, 1967) for prevention

of soil clogging during infiltration. Because of the large pore area and the rapid dispersement of liquid throughout the bed, it is believed that clogging will present only minimal problems for the ET unit.

Location

An evapotranspiration waste disposal unit was constructed near Laramie, Wyoming, at a site near the Laramie City Lagoon Waste Treatment System (Figure 1). The location was chosen because of the altitude of Laramie (approximately 7200 feet above mean sea level) and costs involved in constructing and testing the completed unit. Laramie is located on a high plain with the Snowy Range Mountains to the west approximately 30 miles and the Sherman Hills to the east. The elevation of Laramie is as high or higher than many mountain areas where campgrounds and recreational homes and facilities are located within existing National Forest Lands in the Western United States. The one real problem with the location of the ET unit is that trees and shrubbery do not exist near the unit. As a result, the unit is subjected to a high plains climate rather than a preferred forested area climate.

Construction

An evapotranspiration waste disposal unit for a single family (6 people), high mountain recreational facility was used as the design criteria. Preliminary design indicated that an evapotranspiration unit of the type and size shown in Figure 2 would be adequate to handle a single family dwelling during the summer months in high elevation areas. The ET unit is unique in that it completely eliminates infiltration and a holding tank.

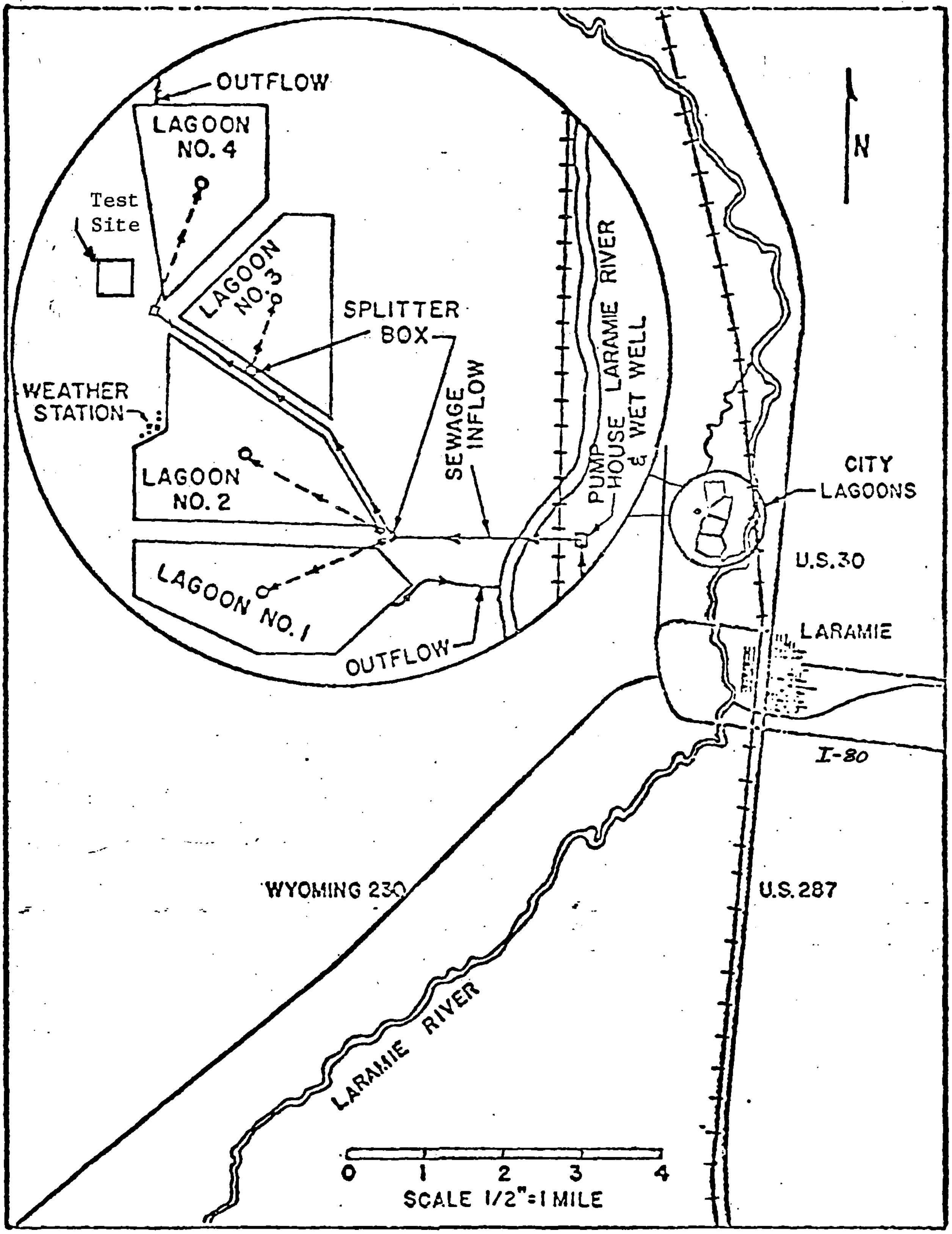
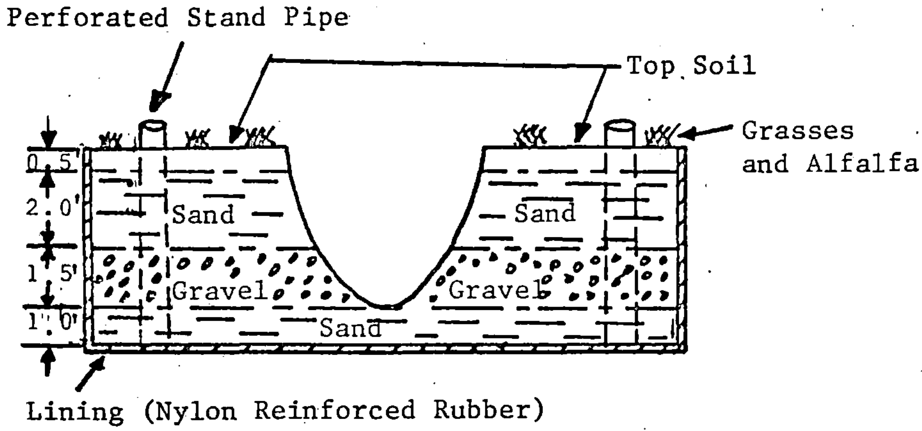


Figure 1. LARAMIE EXPERIMENTAL SITE



Section A-A

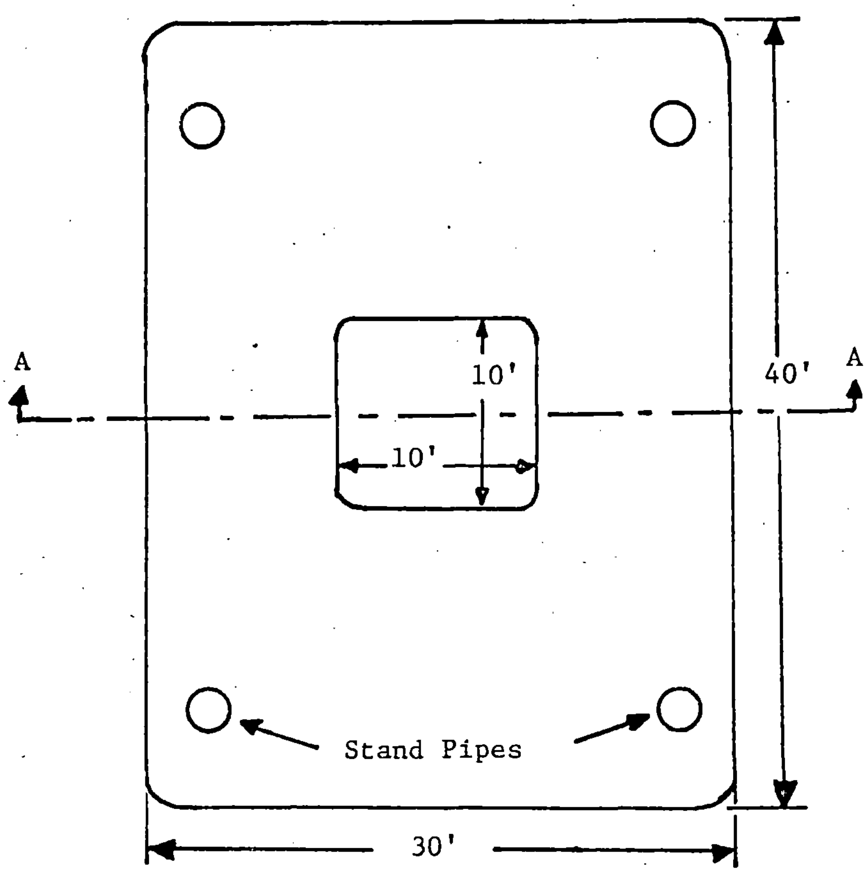


Figure 2. EVAPOTRANSPIRATION UNIT

The hole for the ET unit was excavated with a front-end loader. The natural earth material was such that it would stand almost vertically for a few days without much sloughing. Three sides of the unit were essentially vertical with the fourth side slanted outward as steeply as possible permitting the front-end loader to move in and out of the pit excavation area.

The unit consists of a hole approximately 30 feet wide, 40 feet long and five feet deep with the realization that one size is slanted due to the method of construction. A 22 mil nylon reinforced polyvinyl chloride rubber was used to line and seal the ET unit. The liner was set in by hand. A 12 inch layer of pit run sand was placed on top of the liner in the bottom of the pit. A layer of two- to three-inch washed gravel 18 inches thick was placed on top of the sand. This was topped with 24 inches of sand and six inches of top soil (Section A-A, Figure 2). A center hole approximately ten feet square was formed in the center of the unit and was lined with the gravel material. Four perforated stand pipes were placed inside the unit near the perimeter for monitoring purposes. The stand pipes extended to the bottom of the unit.

The construction of the unit was slightly more difficult and time-consuming than originally anticipated. The arrival of the lining was delayed in shipment until the middle of July. As the lining was the first thing to go into the hole, the entire project was delayed until it arrived.

The first layer of sand had to be spread by hand to prevent the rubber lining from being torn by the loader. This process took about

ten man hours. After this initial layer of sand was placed, successive layers of gravel and sand were moved with a front-end loader which was by far the best method. The gravel and sand could be placed by hand but would take a considerable amount of time. An estimated 30 to 40 man hours would be involved in hand spreading the gravel and an additional 25 to 30 man hours for the sand and topsoil.

Grasses

A mixture of four grasses was planted in the topsoil the second week of August, 1973. These grasses were fawn tall fescue applied at seven pounds per acre, orchard grass at seven pounds per acre, reed canary grass at three pounds per acre, and alfalfa applied at three pounds per acre. These grasses were chosen because they are typical grasses used in Wyoming and have varying root penetration characteristics needed to cause transpiration of water for all levels of waste maintained in the unit.

Unfortunately, the construction phase of this study was not completed in sufficient time to produce large growths of grass before the winter freeze occurred. This resulted in a relatively poor stand the following spring (1974). The area was reseeded the last week of April (1974) and again toward the end of May (1974). The May (1974) planting was necessary due to gophers and prairie dogs eating off the tender new shoots. A screen fence was thus installed around the site of the ET unit. By the end of June, a reasonably good stand of grass was established. At the present time (September, 1974), approximately 75 percent of the unit is covered with healthy stands of grass. The main grasses are orchard and fawn tall fescue.

Loading

The raw sewage used in the ET unit was taken from the Laramie City Lagoon Waste Treatment System at a point just before entering the treatment facility. The sewage was them pumped into the center hole of the ET unit five times each week (Monday through Friday). Because the ET unit was so far from the sewage collection system, a pickup truck and six 55-gallon barrels were used to transport the raw sewage to the ET unit. To pump the sewage into and out of the barrels, a small gasoline-powered generator and an electric pump were used.

The original timetable called for planting the grass and starting the filling sequence about the first of July, 1973. The timetable was set back six weeks due to the late arrival of the membrane liner.

The initial start-up began on August 14, 1973. During the entire fall of 1973, the loading rate was held constant at 300 gallons per day (1500 gallons per week). For the purposes of this study a family of six people yielding 50 gallons of waste water per person per day (Metcalf and Eddy, 1972) was used as the basis for the amount of sewage influent.

Until September 21, 1973, approximately 100 gallons of the raw waste water was sprayed on the surface of the ET unit to help irrigate the new grass seed. The remaining 200 gallons was pumped into the center hole. The loading rate was continued at 300 gallons per day (1500 gallons per week) until October 31, 1973, when snow rendered the ET unit inaccessible.

During this time and throughout the entire study, the liquid elevation was measured in the four stand pipes located in the four corners of the ET unit. The measurements were made just prior to pumping the raw waste water into the ET unit.

From the first part of September until the last of October the liquid elevation in the ET unit stabilized at a relatively constant elevation between 7194.20 feet and 7194.35 feet (Figure 3). Figure 3 and all other figures are shown as weekly averages.

On April 29, 1974, loading was resumed at 200 gallons per day (1000 gallons per week). Then on May 1, 1974 the loading rate was increased to 300 gallons per day (1500 gallons per week), to supplement the irrigation of the new grass seed planted the last week of April. About 100 gallons of the raw waste water was sprayed on the surface of the ET unit. This was continued until the second week of June. From June 6 to June 17, the loading was continued at 300 gallons per day (1500 gallons per week) with no surface irrigation. During this period of time the elevation of the liquid remained fairly constant (Figure 4).

On June 18, 1974, the loading rate was reduced to 200 gallons per day (1000 gallons per week). This is equivalent to 33 gallons per person per day. The effect of the reduced loading rate was noted in the liquid elevation changes. On Monday, the beginning of the loading sequence, the elevation would be noticably lower, but as the week progressed the elevation would climb to a fairly constant level slightly lower than the previous week (Figure 4).

The loading rate was further reduced to 100 gallons per day (500 gallons per week), from July 15, 1974 to July 22, 1974. This would be equivalent to 17 gallons per person per day. The liquid elevation fluctuated in the same manner as it did during the previous loading sequence. First, the liquid elevation drop was substantial over the weekend. The increase in elevation by Friday was very small.

Figure 3. LIQUID ELEVATION 1973
AND LOADING RATE

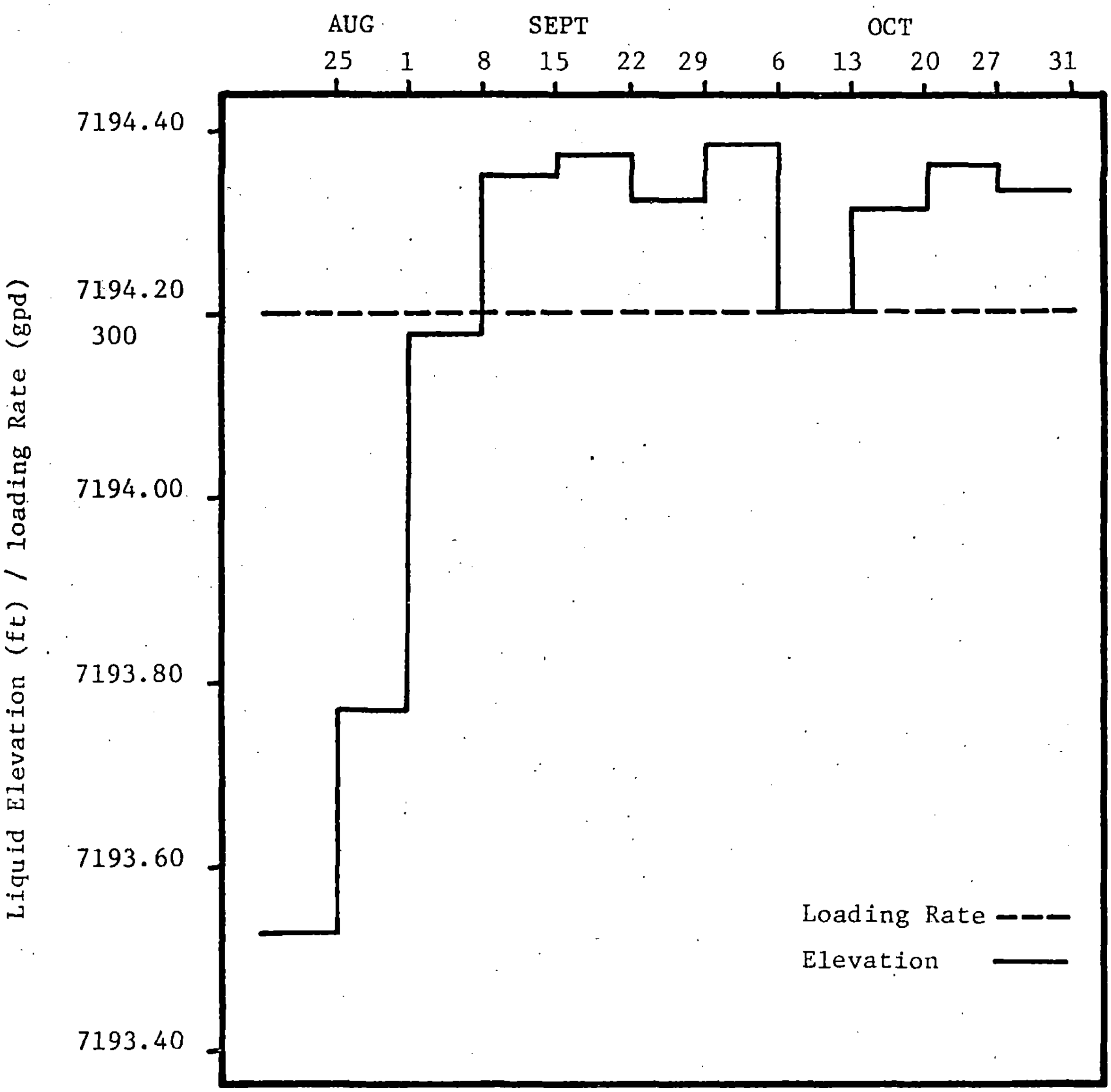
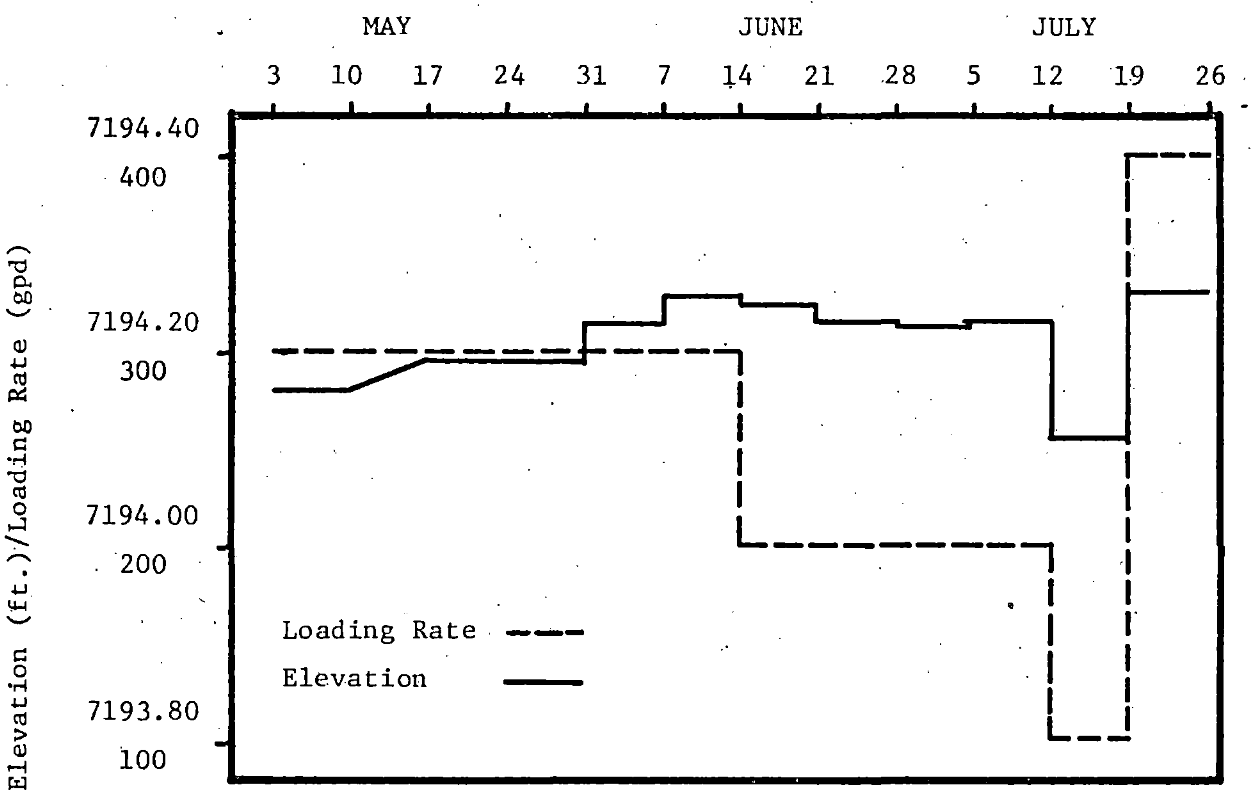


Figure 4. LIQUID ELEVATION 1974
AND LOADING RATE



Due to the large drop in elevation at this loading rate of 100 gallons per day, it was felt that 100-150 gallons per day (500-700 gallons per week) be considered the minimum loading rate. At this time the top soil seemed to dry out quite badly. Although there were no visible signs of grass deterioration, this was probably due to the short period of loading (one week), the deep root system, and possibly the capillary action of the sand bringing the moisture up to the root system.

By increasing the loading rate to 400 gallons per day (2000 gallons per week) on July 22, 1974, it was noticed that the liquid elevation rose almost immediately and held a fairly constant level. Since the increase in elevation was so rapid at first and then abruptly stopping its rapid rise and holding a fairly constant elevation a few days later, it was felt that the level being maintained was possibly not the equilibrium point. A few days after this occurrence, plants and grasses outside the ET unit on the west side started turning green. By excavation with a shovel, the membrane along the west side of the unit was exposed and it was found that during construction, the west side of the membrane had slipped down approximately eight inches below ground surface. This facilitated the leaking of liquid out of the ET unit, thus giving false liquid elevation readings.

The elevation of the liquid was reduced and the west side excavated approximately one foot. By cementing a 15 inch strip of membrane onto the existing edge, the ET unit was again sealed to the ground line. Due to measurements made of the elevation of the "sagging" side, it was shown that the deliquent edge was still higher than any of the previous liquid elevation readings, thus, little or no error

should be introduced into the liquid elevation readings up to the time of the 400 gallon per day loading sequence.

Sampling

Two samples were taken each time new sewage was introduced into the ET unit. The first sample was of the raw sewage, taken as the waste water was being pumped from the Laramie Sewage Collection System. The second sample was taken alternatively from one of the four stand pipes located in the four corners of the ET unit. The relative elevation of the top of each of these stand pipes was known, so that just prior to introducing the new raw sewage, the elevation of the liquid in all four stand pipes was measured and averaged.

Types of Tests

It is assumed the ET unit has no effluent since there are no holes in the unit. Therefore, there is no need to monitor waste water parameters so as to remain within EPA guidelines. To better evaluate the efficiency of this type of sewage treatment facility, however, parameters such as BOD, solids and total coliform count were measured on a regular basis and the results from the effluent and influent compared. In addition, tests were made randomly to measure pH, temperature, dissolved oxygen, magnesium, calcium and sodium.

All of the tests were preformed according to Standard Methods of Examination of Water and Wastewater.

To determine the salinity and alkalinity of the ET unit water with time, a sample was taken. The electrical conductance, sodium, magnesium and calcium content was measured from this sample. The sodium

adsorption ratio (SAR) can then be calculated from sodium, calcium and magnesium. The SAR, together with conductivity, can be used to find the water quality (Agricultural Handbook, 1954). The SAR was 2.75 on a milli-equivalent basis or 11.70 on a ppm basis. This puts the quality in the C3,C4-S1 range. The C3-C4 is high to very high salinity hazard while the S1 signifies low sodium hazard. This was taken about the first of August 1974. The conductivity was 2200 micromhos per centimeter (EC x 10^6). These values are still way below (only 1/4 to 1/3) the point for retarding grass growth due to a salts build up.

Results from Sampling

The following pages are graphs of the regularly monitored data, as weekly averages, for late summer and early fall of 1973 and the spring and summer of 1974.

Figures 5 and 6 show the biochemical oxygen demand (BOD) which is a measure of the strength of the waste. The typical BOD removal of the ET unit is approximately 65 to 75 percent. Removal efficiences for BOD for a typical secondary effluent would be on the order of 80 to 90 percent.

Total coliforms are shown in Figures 7 and 8. Total coliforms are an indicator of possible pathogenic organisms present in the water, but it is somewhat limited in that viruses and other pathogens such as solmanella could be present with no coliforms present. The ET unit has a removal rate of 99 - 99.99 percent. Average effluents from other treatment processes have removal rates ranging from 90-99 percent.

Some effluents are chlorinated to the point of killing all coliforms, however.

Figures 9 and 10 and 11 and 12 indicate total solids and total volatile solids, respectively. Little significance is placed on total or total volatile solids except to get dissolved solids. Volatile solids is an indicator of the amount of carbonacious organic material that could be oxidized or removed from the system, however.

Figures 13 and 14 and 15 and 16 show the total dissolved solids and total volatile dissolved solids, respectively. These parameters are important in that plants are sensitive to dissolved solids (salts) build up. Besides the liquid elevation, the dissolved solids is probably one of the most important parameters monitored. The unit's life span will probably depend on the dissolved solids build up.

Total suspended and total volatile suspended solids are shown in Figures 17 and 18 and 19 and 20, respectively. Suspended solids is more or less an indicator of the amount of material that can be filtered out. The ET unit is removing 60 to 80 percent of the suspended solids. Typical treatment units generally remove between 50 and 92 percent of the suspended solids.

Figure 5. BIOCHEMICAL OXYGEN DEMAND 1973

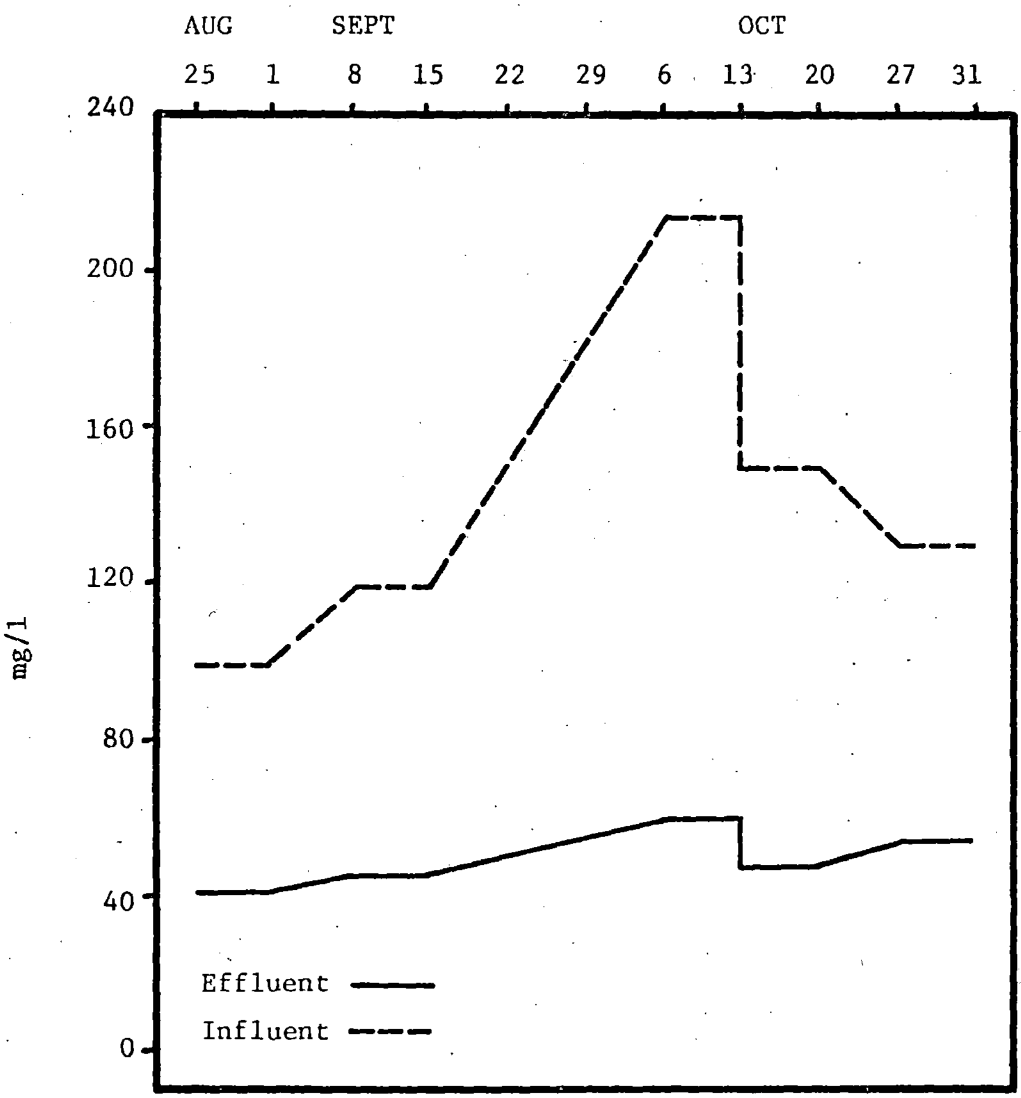


Figure 6. BIOCHEMICAL OXYGEN DEMAND 1974

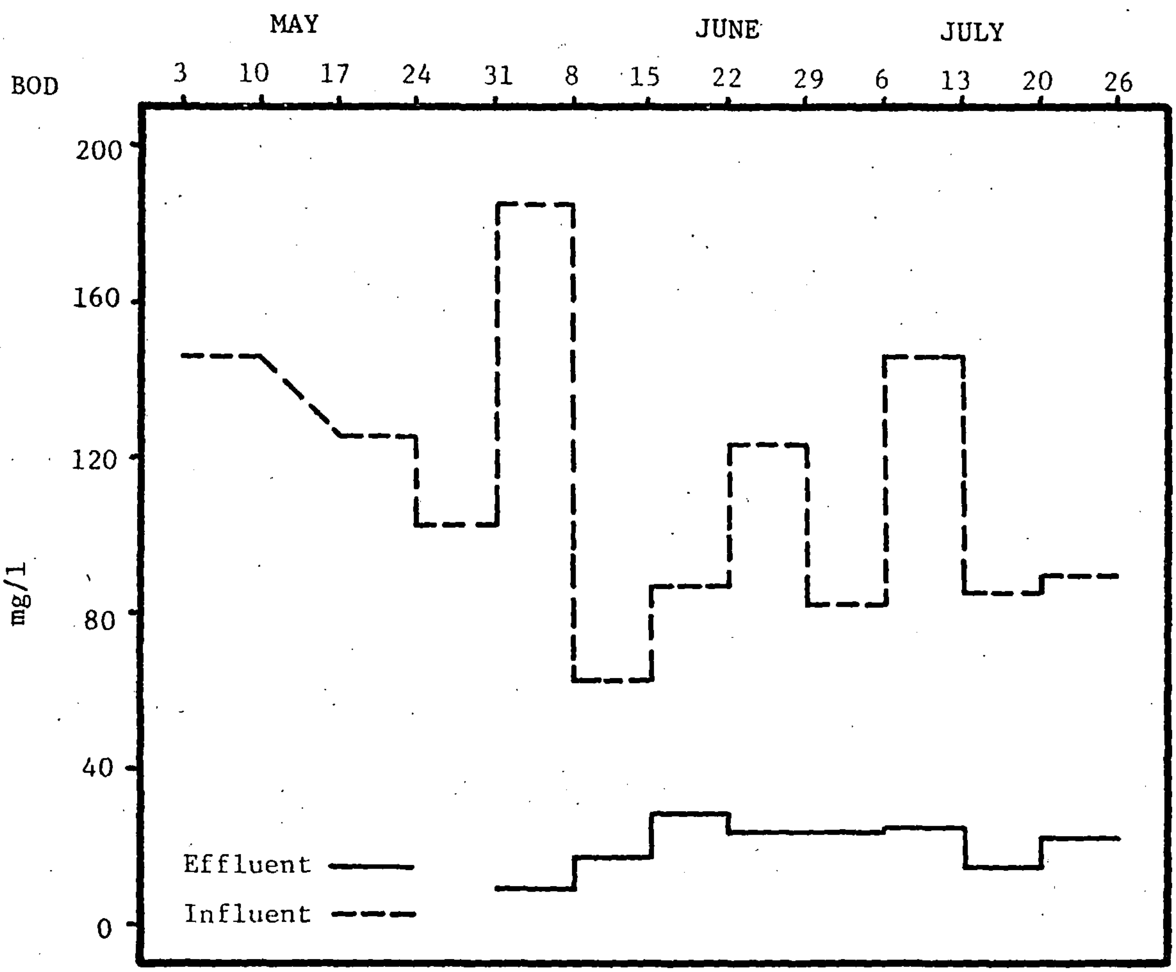


Figure 7. TOTAL COLIFORMS/100 ml 1973

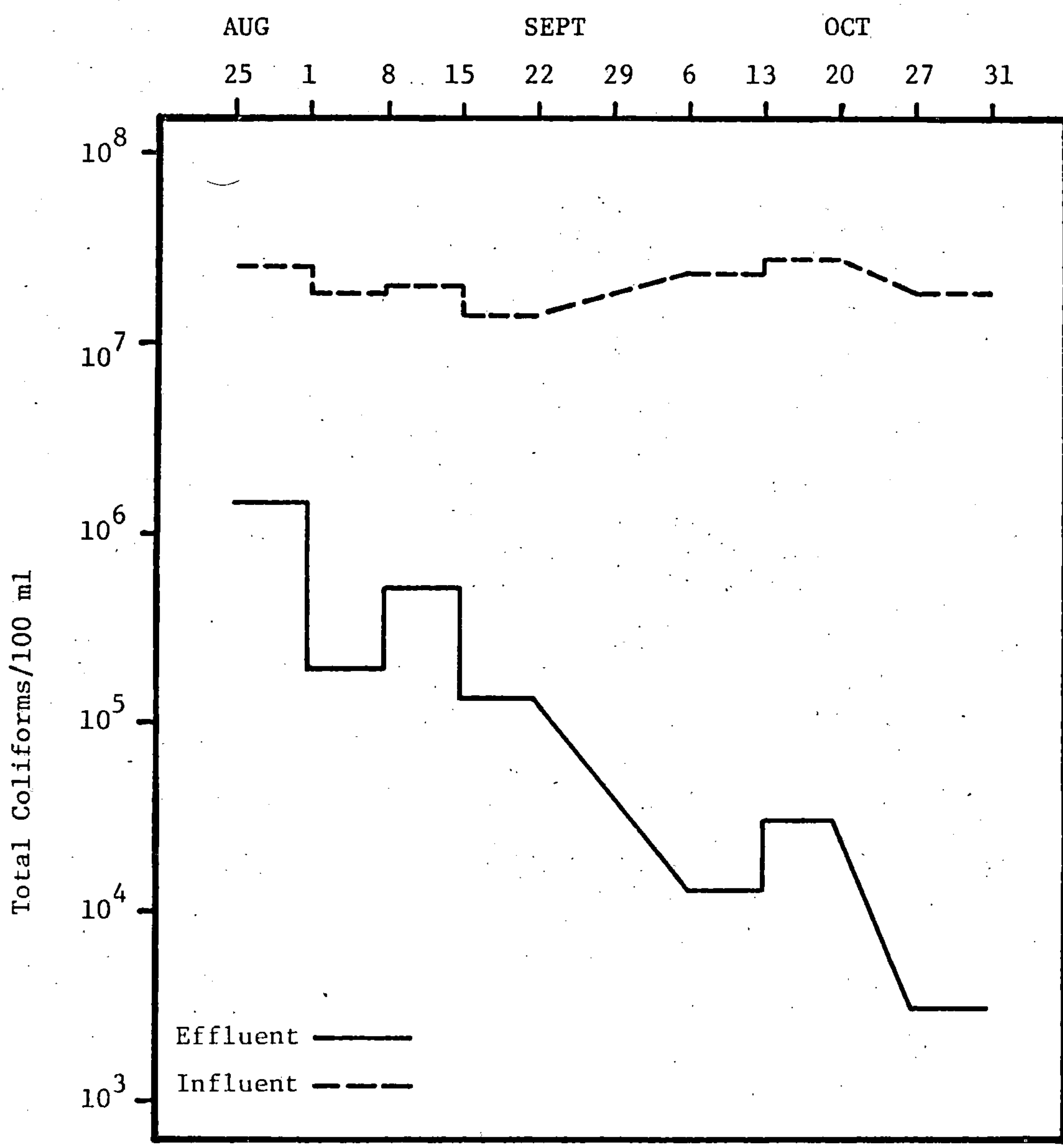


Figure 8. TOTAL COLIFORMS 1974

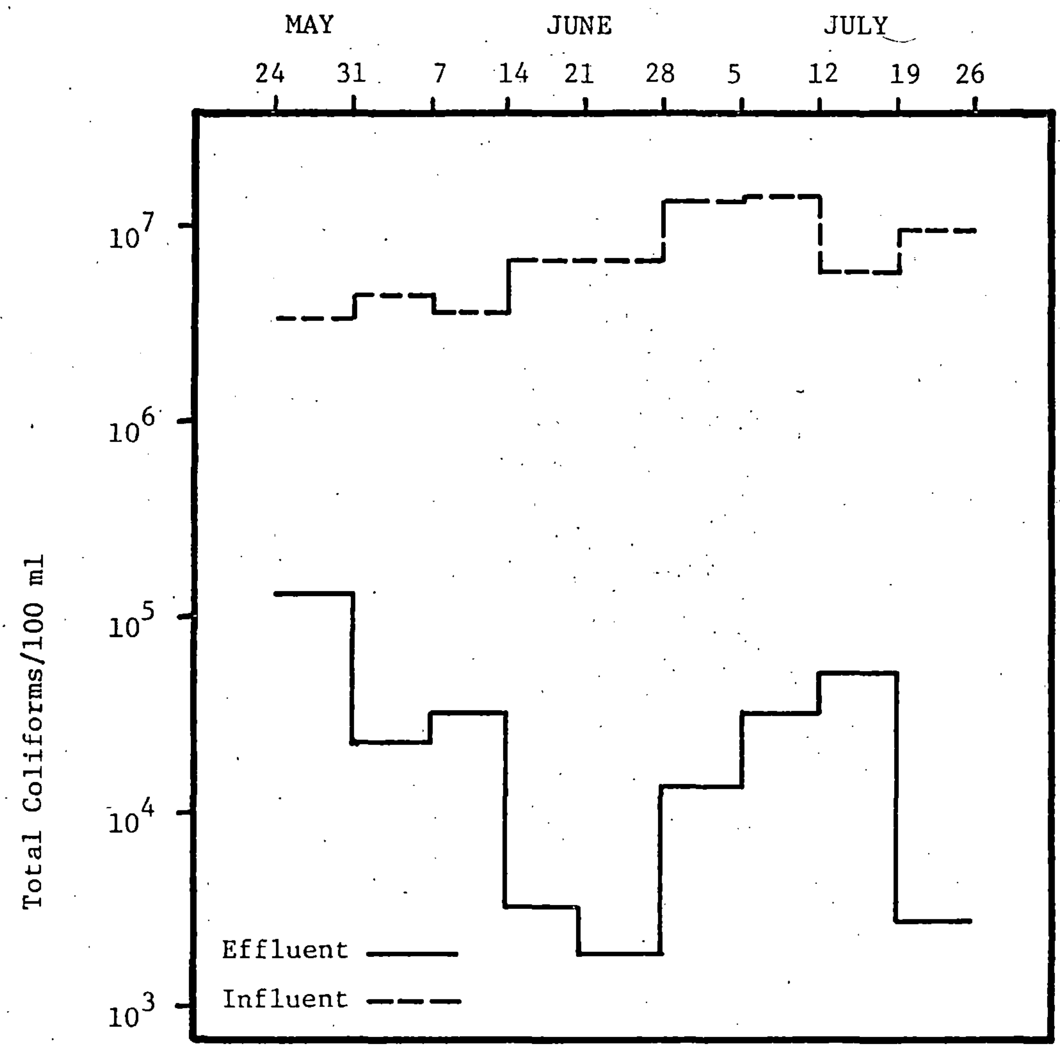


Figure 9. TOTAL SOLIDS 1973

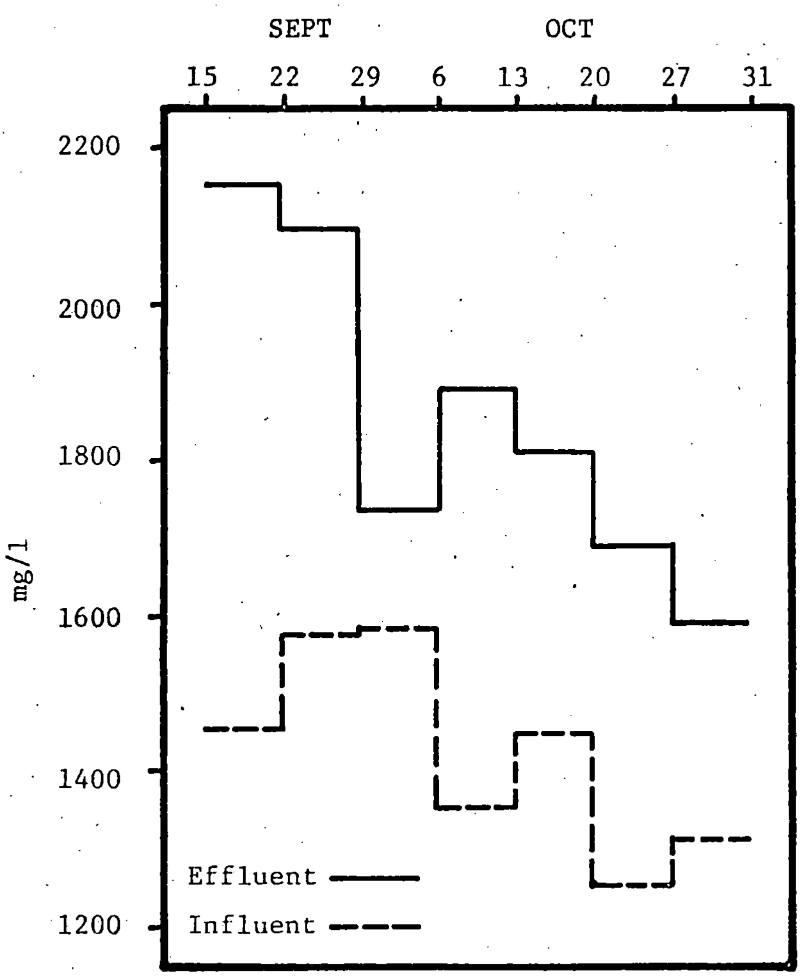


Figure 10. TOTAL SOLIDS 1974

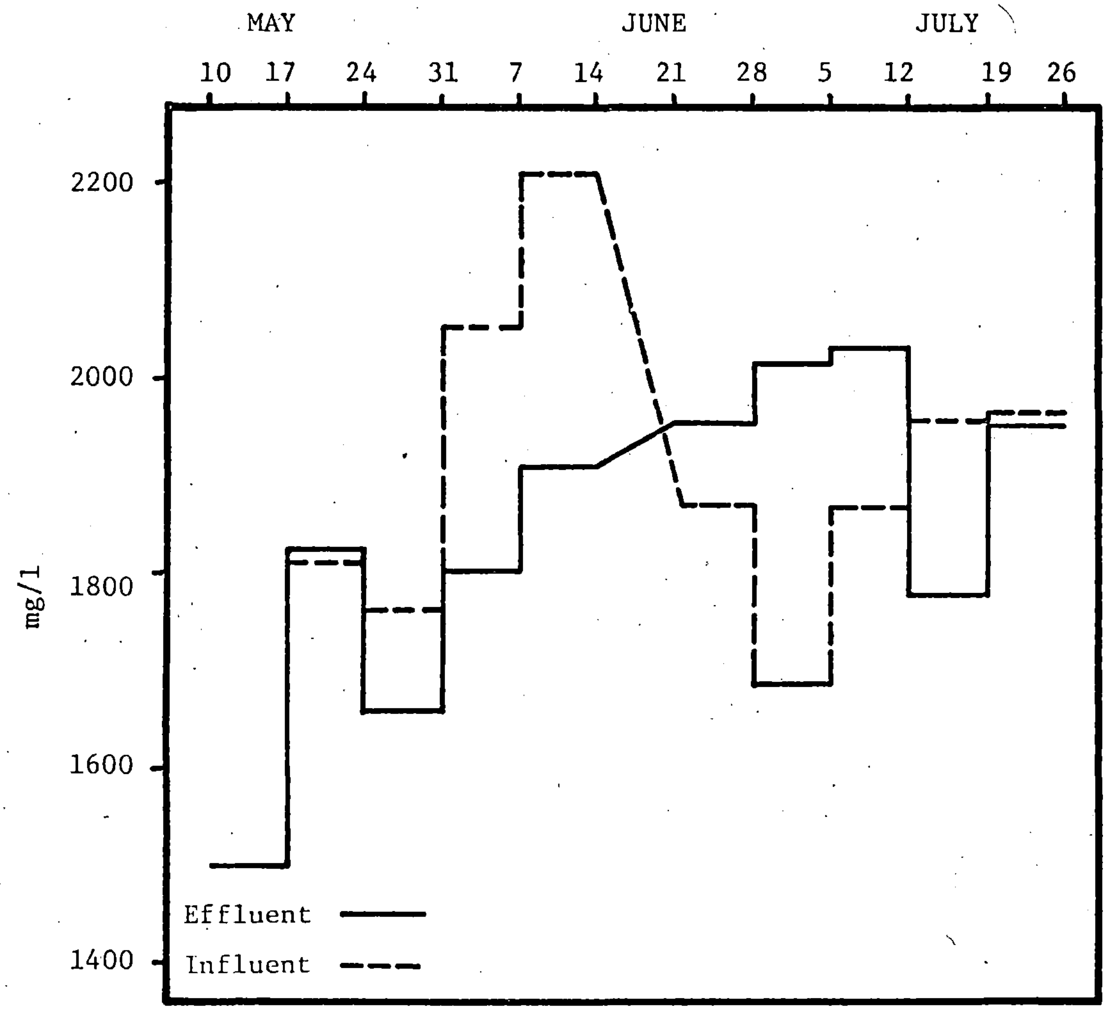


Figure 11. TOTAL VOLATILE SOLIDS 1973

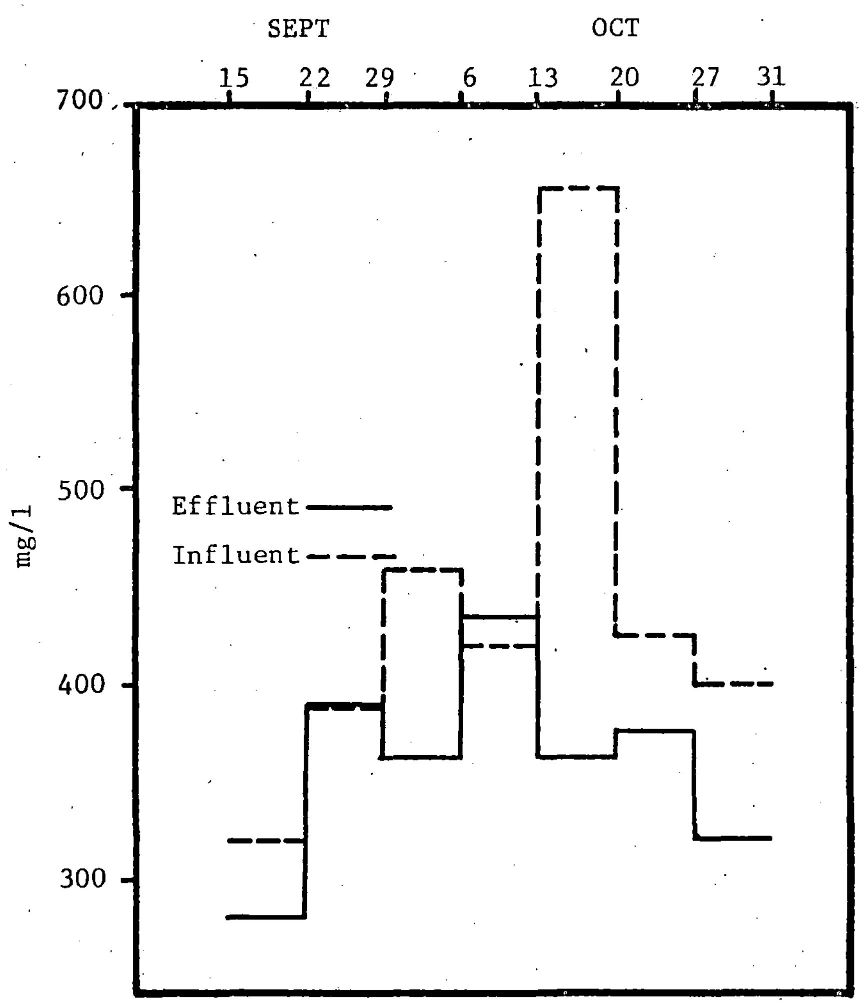


Figure 12. TOTAL VOLATILE SOLIDS 1974

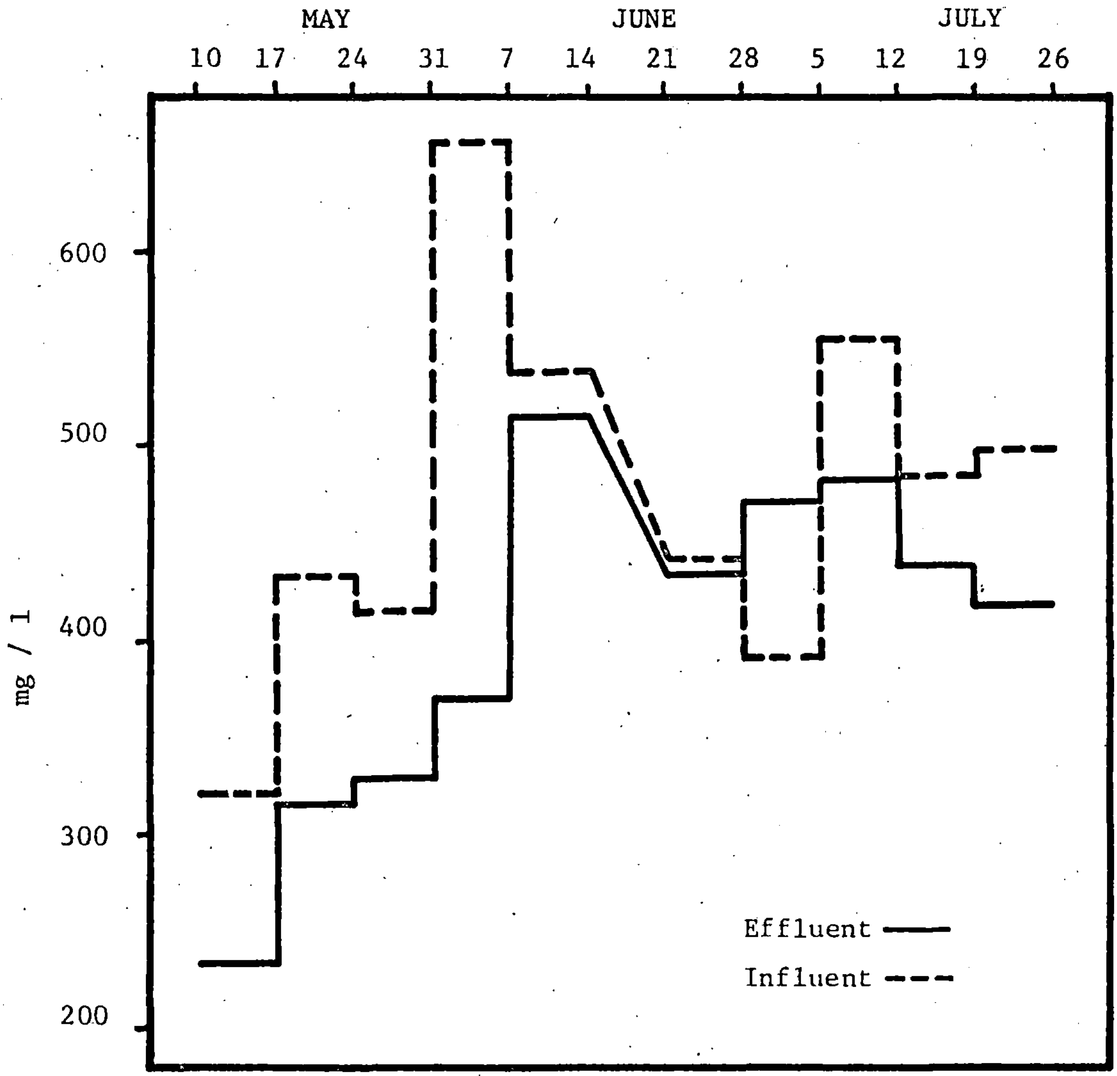


Figure 13. TOTAL DISSOLVED SOLIDS 1973

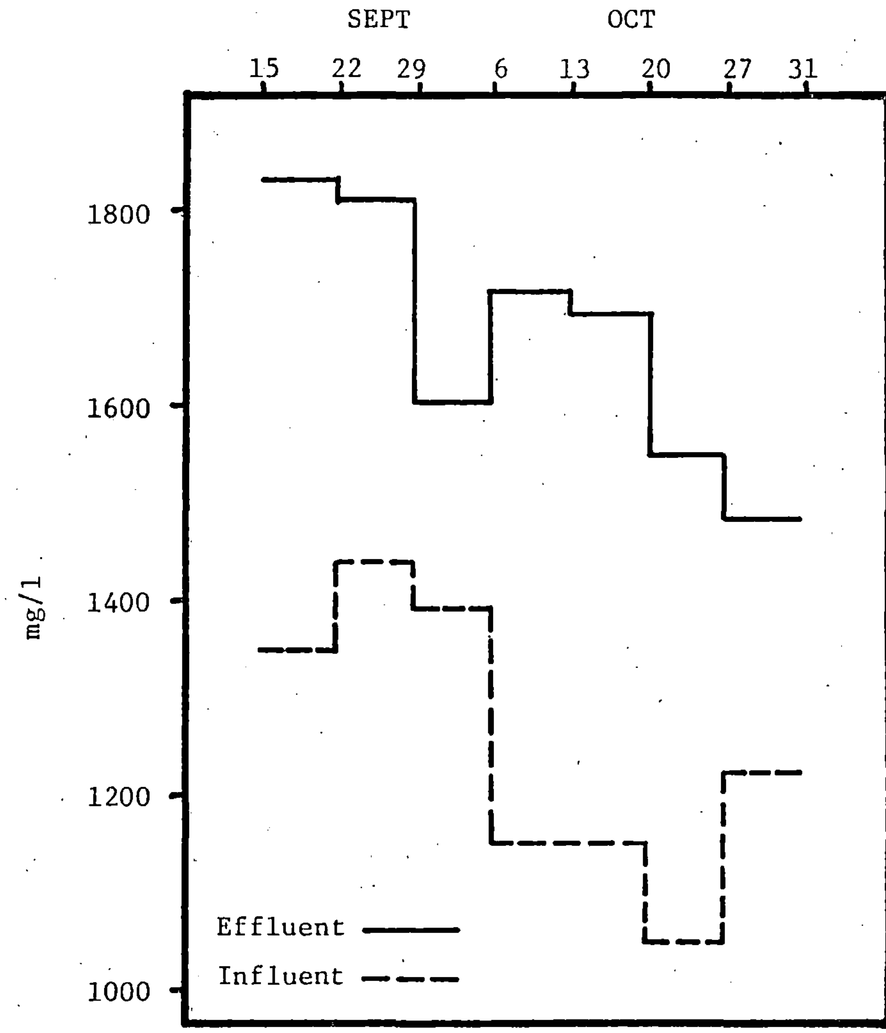


Figure 14. TOTAL DISSOLVED SOLIDS 1974

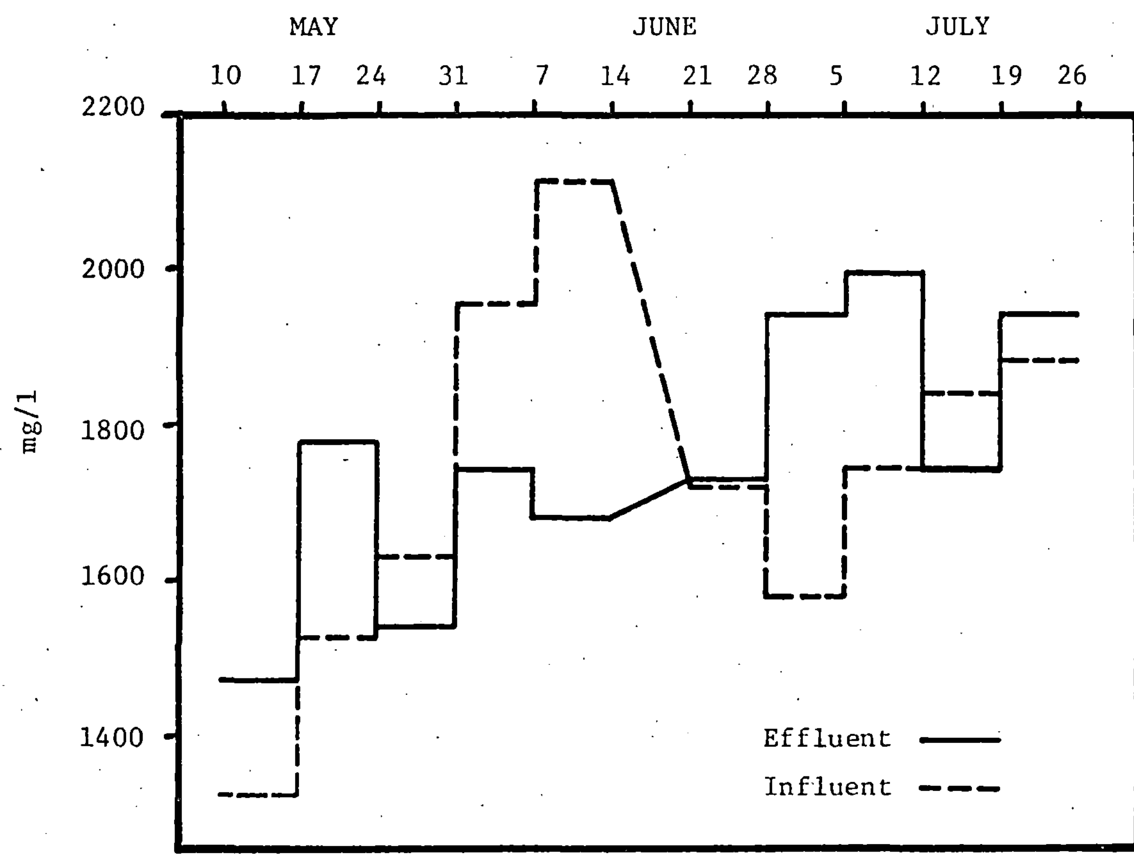


Figure 15. TOTAL VOLATILE DISSOLVED SOLIDS 1973

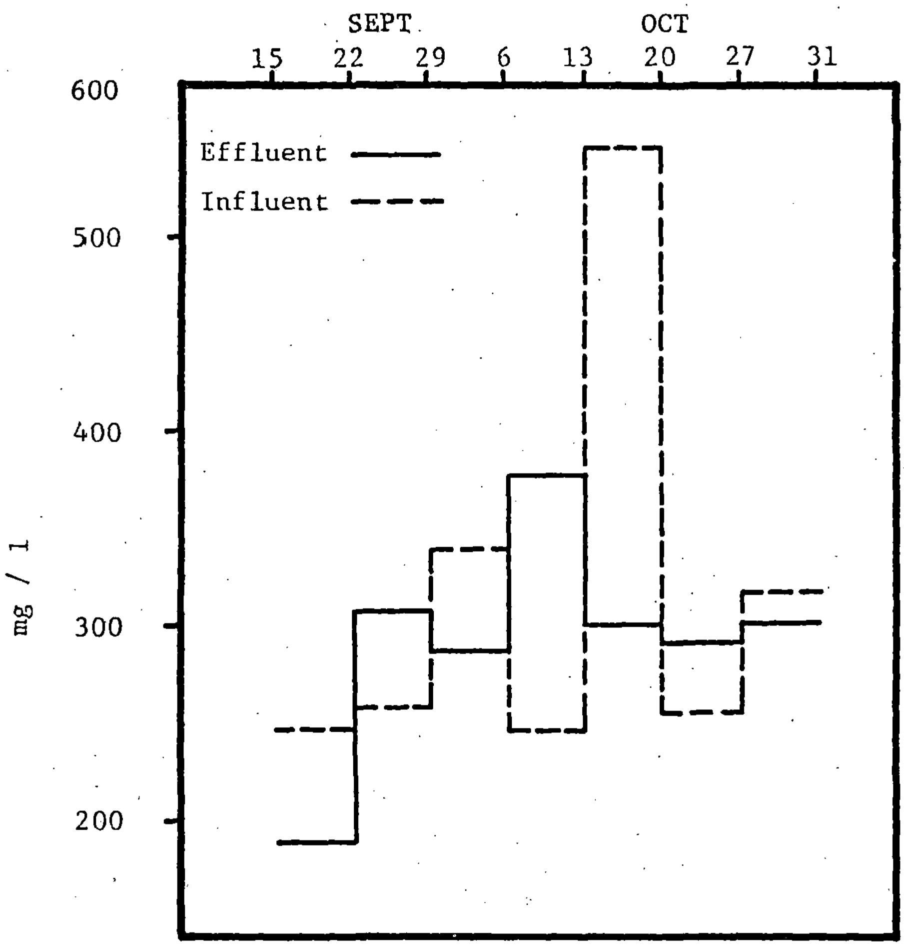


Figure 16. TOTAL VOLATILE DISSOLVED SOLIDS 1974

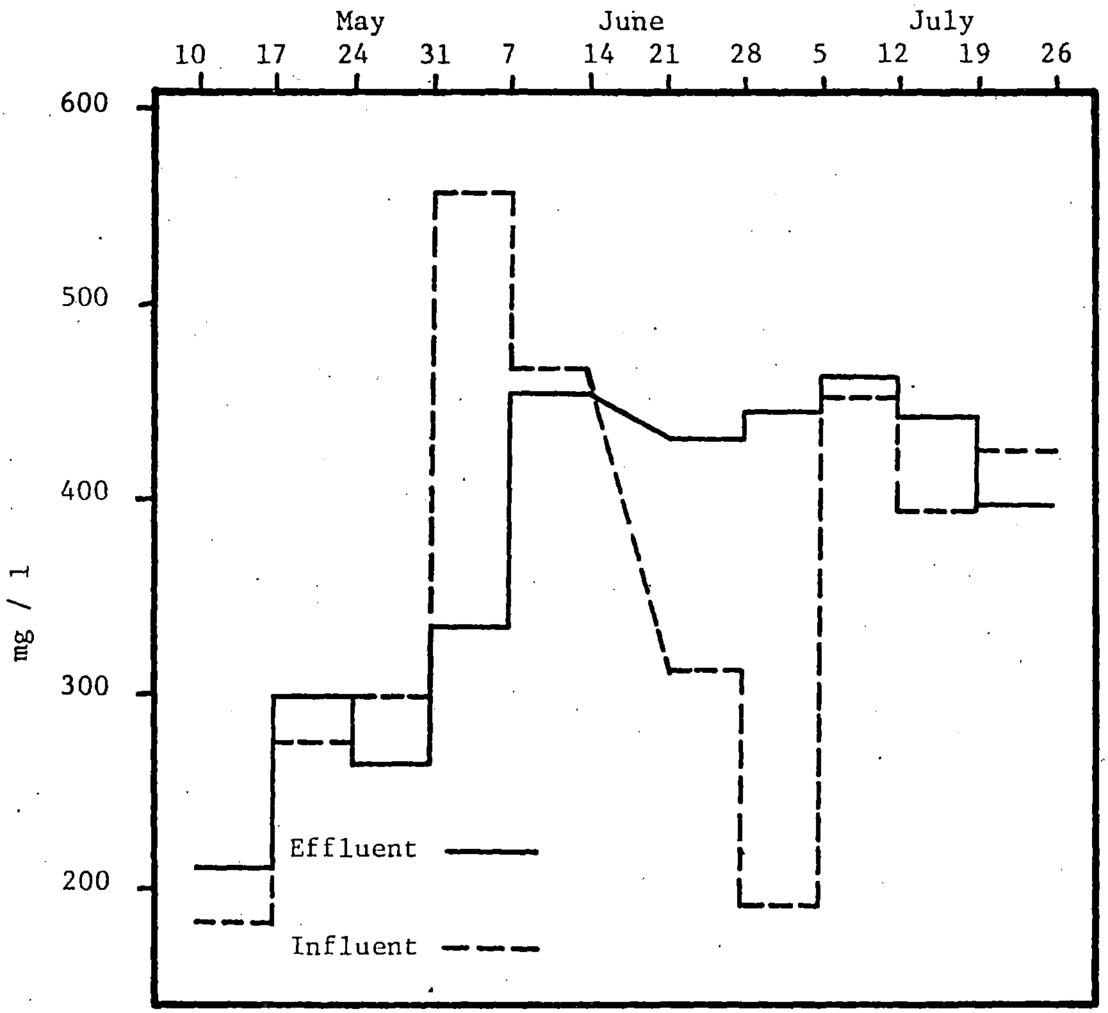


Figure 17. TOTAL SUSPENDED SOLIDS 1973

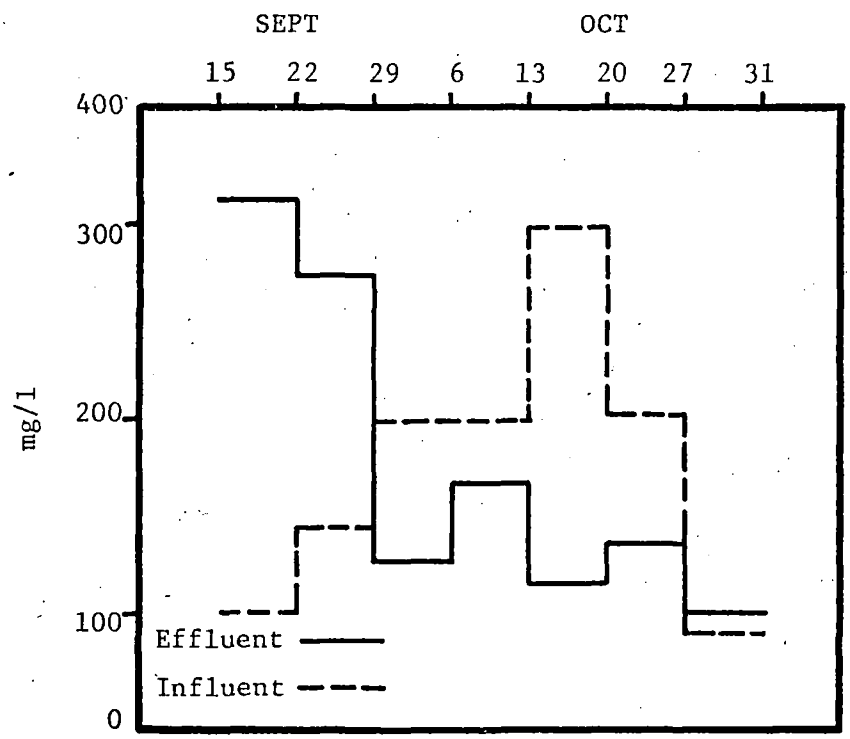


Figure 18. TOTAL SUSPENDED SOLIDS 1974

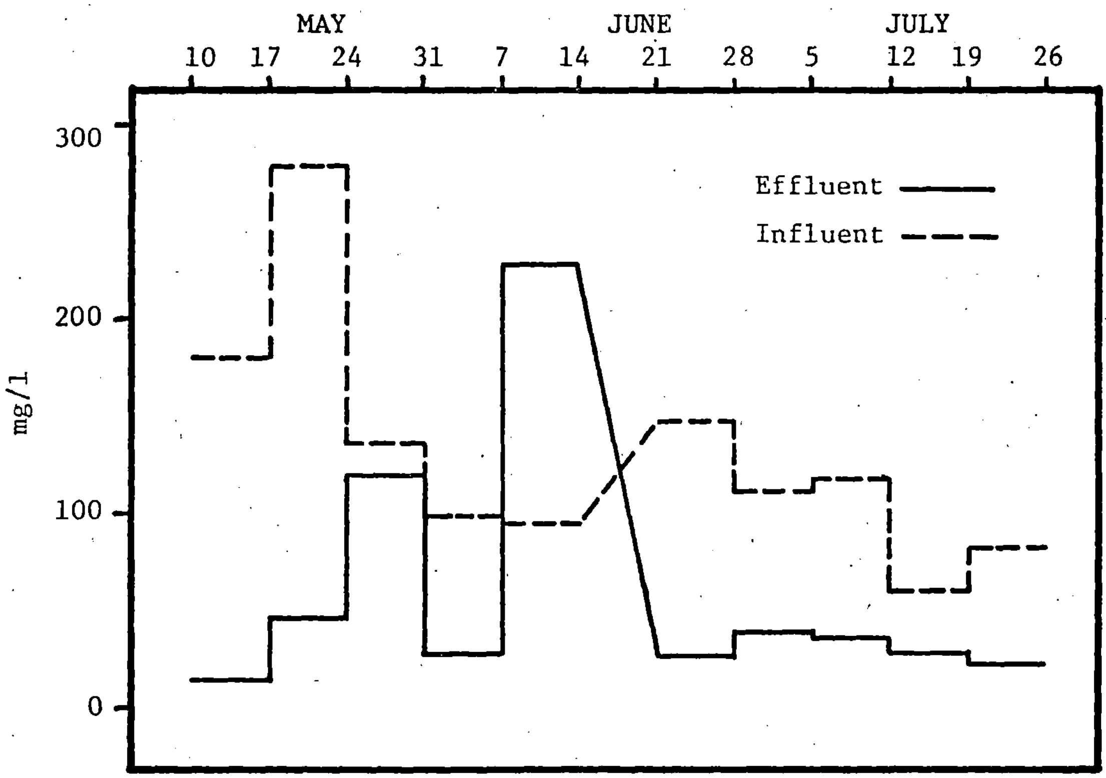


Figure 19. TOTAL VOLATILE SUSPENDED SOLIDS 1973

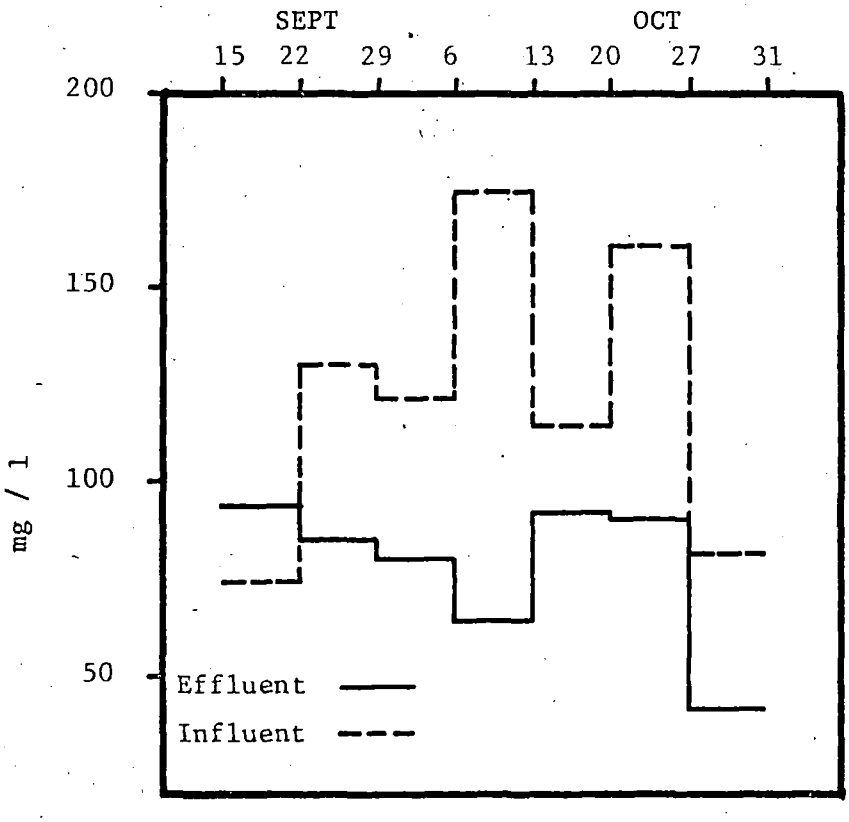
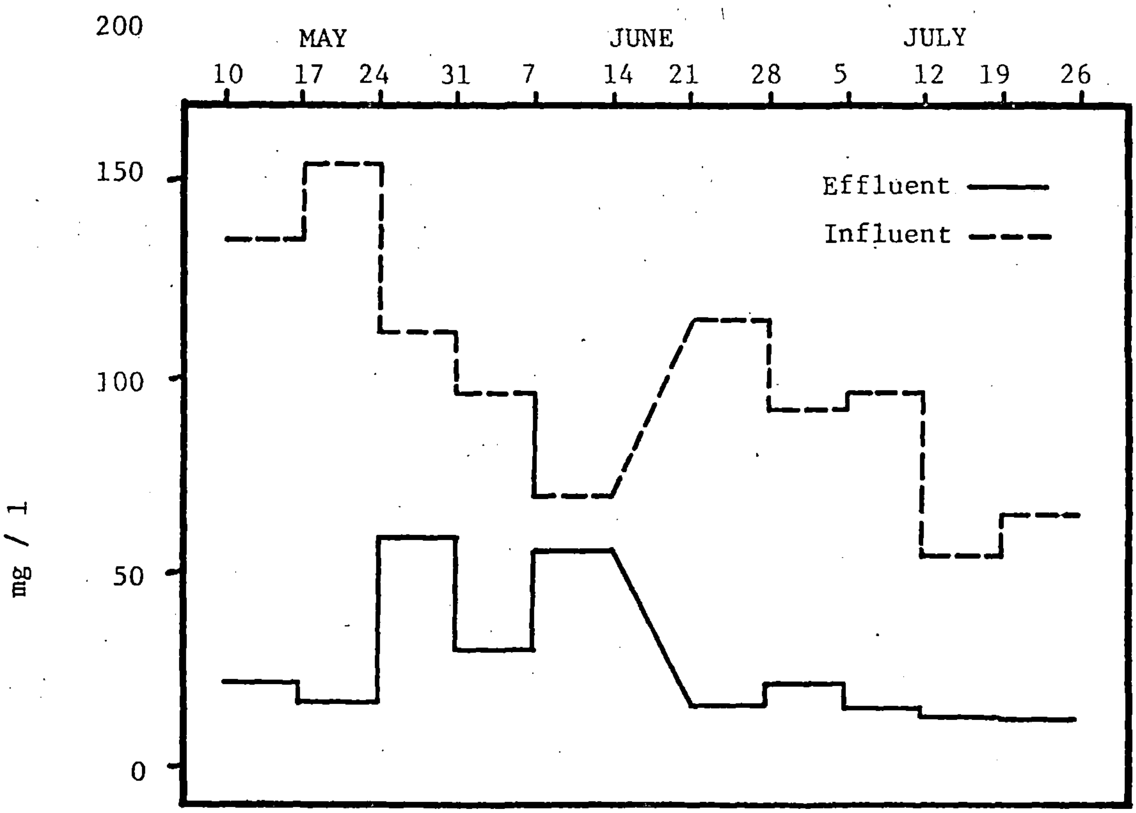


Figure 20. TOTAL VOLATILE SUSPENDED SOLIDS 1974



DISCUSSION OF RESULTS

Operating Conditions

From liquid elevation measurements, Figures 3 and 4, it was apparent that the minimum loading rate should be held at between 100 and 150 gallons per day (500 to 750 gallons per week) during the growing season which is essentially between freeze dates. If a lower loading rate were used, the liquid level is likely to drop far enough below the grass root zones that capillary action of the soil would not be great enough to get water to the root systems of the grass. However, capillary action of the system seems to be relatively good. When the liquid level reaches within approximately 14 inches of the soil surface, the soil surface remains in a fairly damp state.

The minimum loading rate can be reduced below the above stated values before and after the freeze dates depending on the plant uptake of the sewage and the amount of evaporation from the center pond and bare ground areas. Once again these loading rates are for an ET unit with a surface area of 1200 square feet.

The maximum amount of influent to the ET unit should be set at approximately 300 gallons per day (1500 gallons per week) during the period between freeze dates. More than this amount may cause the unit to overflow if continued for a period of one to two weeks.

The detrimental effects of overloading the system would probably be the killing off of some of the grass species and the subjection of the topsoil layer to a higher salts and total solids concentration. The net result would probably be a decrease in loading capacity and efficiency of the unit.

Before and after the freeze dates the maximum loading conditions will have to be decreased due to a decrease in the evapotranspiration of the unit.

Fluctuations in the liquid level in the ET unit have not seemed to harm the grasses growth rates as long as moisture is available to the root system. The alfalfa and reed canary plants have had a fairly difficult time establishing themselves in the unit, however.

Pollution Parameters

Although the ET unit does not allow any leaching into the groundwater or outflow into surface streams, a measure of selected pollution parameters can give an indication of how efficient this type of unit can be for treatment of raw sewage. Measurement of total solids built up in the system can also give an indication of the life of the unit either due to clogging of the sand and gravel filter system or reaching the salt tolerance of the plants growing on the unit. At the present time, the unit has indicated no clogging is occurring and the electrical conductance shows the salt concentrations to be far below the minimum tolerance levels of the grasses.

Figures 5 through 20 gave comparisons of the selected pollution parameters, BOD, total coliforms, total solids, total volatile solids, total dissolved solids, total volatile dissolved solids, total suspended solids, and total volatile suspended solids for the influent raw sewage water and the water in the ET unit for the period of operation.

It can be noted from Figures 5 and 6 that the BOD was reduced from 100-120 mg/l to 30-40 mg/l between influent and the ET unit water. This indicates significant treatment of the raw waste material by the unit. A sizeable reduction of total coliforms, on the order of three to four

orders of magnitude (10^7 organisms/100 mil to 10^4 organisms/100 mil), is indicated by Figures 7 and 8. This reduction in total organisms is on the order of 99 to 99.9 percent removal. Possible reasons for this high removal rate are the long detention time or relatively high salts content.

The fixed or total solids of the unit generally decreased during 1973 and then during the 1974 season have either increased or held essentially steady (Figures 9 and 10). The total volatile solids have generally increased within the unit.

Dissolved solids was generally the main constituent of the total solids class. This says that if the unit becomes inactive because of solids build-up it won't be the total solids that physically clog the subsurface but the dissolved solids (salts). This could materially affect plant growth at some date in the future. As stated before, the electrical conductance (a measure of the salt build-up) is still only 25 to 30 percent of the level of retarding growth of the grasses used. Due to the short period of operation of the ET unit and the inconsistency of the data (going down in 1973, then slowly going back up in 1974), it would be very risky to try and forecast the life of the system at this time. There isn't enough data to establish a base. The indication is that the unit <u>may</u> have to be flushed at sometime in the distant future.

The efficiency of the unit has to some extent already been discussed. The ET unit is removing between 65 and 75 percent of the BOD while a typical secondary effluent removes between 80 and 90 percent of the BOD. It is interesting to note, however, that the BOD's of the waste water in the ET unit are in the 30 to 40 mg/1 range and EPA

standards say the maximum allowable BOD is 30 mg/l. Therefore, the ET unit compares favorably with EPA standards if the unit had an outfall. The total coliform removal of the ET unit is better than most typical secondary effluents except those that chlorinate. Suspended solids from the ET unit are in the middle of the range of typical secondary effluent removals of the same quantities. Therefore, the ET unit is acting very much like a fairly typical secondary effluent removal system in its efficiency.

One very interesting point that the data indicate is that the ET unit is a very stable unit. Even though the influent has fluctuated at times to the point of being shock loaded, the ET unit has essentially dampened out this effect. This is a very important quality of the ET unit for use in recreation and summer home areas because many times this type of unit would be subjected to shock loads during weekends when heavy use is incurred.

The ET unit is an anerobic system of treatment of the waste. Gas bubbles are noted escaping reuglarly from the hole in the center of the unit. While excavation was taking place for repair of the liner on the west side of the unit, a sample of the material from about two feet below the ground surface was taken. The sample was very black in color with a small odor present. The rich black color indicates that good biological action is occurring with the waste material.

Asthetic Characteristics

The surface area of the ET unit is approximately 1200 square feet. It is essentially covered with a good stand of grasses except where

the ten-foot square hole exists in the center of the unit. The lush growth of grass on the unit makes it asthetically pleasing. At first weeds showed up on the unit, but as time passed the weeds were pulled, leaving just the grasses. A few bare spots still exist on the unit which at times is not to pleasing to the eye when dried out.

The center hole in the unit is at times quite unsightly. The algae growth turning the water green and the scum, etc. on top of the water make it somewhat unpleasant to focus upon. It would be suggested that some sort of board or aluminum cover be placed over the center hole which would fit in with the surrounding environment. The cover should be made so that plenty of open area still existed throughout the cover for evaporation from the hole. The cover would accomplish two purposes: (1) it would made for more pleasing asthetic beauty and (2) it would eliminate the possibility of someone falling into the hole and possibly drowning.

Little or no odors have been detected coming from the ET unit. It is quite satisfactory in this respect. At times, however, flies and mosquitos are found on or near the water. The number of these insects has not indicated a nuisance problem.

COSTS AND OPERATION OF ET UNITS

To help evaluate and size this type of sewage treatment system for other climates and varying loading rates depending on the estimated human use of the particular facility (i.e., campground, recreational park, summer home, etc.), correlation of actual evapotranspiration from the unit with existing weather data information near the ET unit site was

investigated. Five existing evapotranspiration equations were selected to predict the evapotranspiration occurring from the ET unit using weather data from a meteorological site approximately 1/4 mile from the unit. A comparison between the liquid level in the unit and the estimated evapotranspiration by the equations was made.

The use of a publication just recently in print (1974) "Consumptive Use of Water and Irrigation Water Requirement" edited by M.E. Jensen and suggestions by one of the contributors to the publication results in the selection of the five evapotranspiration equations which supposedly would give the best results for this area of the country. The equations used were Penman, Blaney-Criddle, Kohler, Nordensen and Fox Lake Evaporation, Christensen Pan Evaporation, and Oliver. From a study of these methods, it was found that none of them correlated well with liquid level in the unit and actual values of influent added. A process now being tried is a multiple correlation between Class A pan evaporation, solar radiation and evapotranspiration.

It is hoped that some method of correlation between evapotranspiration equations and the unit can be determined in the near future so that loading rates can be determined for areas with differenct climatic and surrounding cover conditions. Ths is an important consideration since sizing of a unit on surface area and conditions occurring at a particular site without regard for different surrounding cover and climatic conditions could be disastrous. Therefore, sizing of ET units for different purposes can only be done at the present for areas with essentially the same climate and surrounding cover conditions as the present ET unit. The sizing can then be done on strictly a surface area basis.

The costs of installing such a unit as the one described in this paper are very favorable. The cost of installing an ET unit are in the same category of costs as those associated with a septic tank and leach field arrangement.

The cost of the liner for an ET unit will run between \$0.40 and \$0.50 per square foot (\$750 to \$950 for a 1200 square foot surface area). The sand, gravel and topsoil will cost between \$3.50 and \$3.75 per cubic yard on the average for short haul distances (\$780 to \$840 for a 1200 square foot surface area). However, hauling distance of the material may significantly affect the cost of the fill material. The use of a front-end loader and labor will vary. It is estimated that the loader will be needed for one day (8 hours) and that the man hours of labor involved will be approximately 20 for a 1200 square foot surface area unit. Grass, piping to the unit and other supplies will also have to be provided. The total cost of these items (loader, manpower and supplies) should run approximately \$350 - \$400. Thus, an ET unit installed would cost between \$1900 and \$2200 for a 1200 square foot area. These figures are based on values which are between three and twelve months old. With the above cost figures, prices for larger or smaller units could also be obtained. The cost of the unit could be materially decreased if a part or all of the existing site material could be used in the constructed ET unit. If a cover is placed over the center hole, its cost would have to be included in the price of the unit.

Once the unit is installed the only costs associated with the unit would be for repairs of the influent line. No real operating costs need be considered for this type of unit.

SUMMARY

A summary of the results obtained for the ET unit tested under this research contract are listed below.

1. The maximum and minimum loading rates for the unit during the summer months (between freeze dates) is 300 gpd (1500 gallons per week) and 100-150 gpd (500 to 750 gallons per week), respectively.

2. The efficiency of the unit is typical of secondary effluent treatment systems.

3. The unit indicates that it essentially dampens out the effects of shock loads.

4. The unit is treating the sewage by anerobic processes.

5. Asthetically the unit could be made pleasing with essentially no odors present.

6. It is unclear whether or not the unit can be sized for locations with different climatic and surrounding cover conditions.

7. The cost of the unit is in the same general category as septic tanks with leach fields.

8. Operating costs of the unit are essentially zero.

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